IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Application of: Ganguli, et al.	§	
	§	Group Art Unit: 1792
Serial No.: 10/811,230	§	
Confirmation No.: 8995	§	
	§	Examiner: Stouffer
Filed: March 26, 2004	§	
For: Ruthenium Layer Formation for Copper Film Deposition	§	

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Commissioner for Patents
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1/20/09 — Keith M. Tackett
Date

Dear Sir:

REPLY BRIEF TO EXAMINER'S ANSWER DATED DECEMBER 29, 2008

Applicants submit this Reply Brief to the Board of Patent Appeals and Interferences on appeal from the decision of the Examiner of Group Art Unit 1792 dated April 8, 2008, finally rejecting claims 1, 2, 4-7, 9-14, 16, 17, 19, 20, 22-25, 27, 28, 30-33, 35-38, 40-42, 44-46, 48-51, and 53-67. One copy of this Reply Brief is submitted for use by the Board. While Applicants maintain each of the arguments submitted in Applicants' previously submitted Appeal Brief, Applicants make the following further arguments in light of the Examiner's Answer.

This Reply Brief is believed to be timely since transmitted by the due date of February 28, 2009, as set by mailing date of the Examiner's Answer mailed December 29, 2008. Please charge any additional fees that may be required to make this Reply Brief timely and acceptable to Deposit Account No. 20-0782/APPM/005975.P2/KMT.

ARGUMENTS

Based on the remarks presented in the Examiner's Answer dated December 29, 2008, Applicants supplement their arguments A-C as follows.

***Aaltonen et al., Kawano et al.* and paragraphs [0068]-[0069] of the instant specification[1] do not render claims 1, 2, 4-7, 9-14, 16, 17, 19, 20, 22-25, 27, 28, 30-33, 35-38, 40-42, 44-46, 48-51 and 53-67 obvious**

Claims 1, 2, 4-7, 9-14, 16, 17, 19, 20, 22-25, 27, 28, 30-33, 35-38, 40-42, 44-46, 48-51 and 53-67 stand rejected under 35 U.S.C. § 103(a) over U.S. Patent Application Publication No. 2003/0165615 to *Aaltonen et al.* in view of U.S. Patent No. 6,605,735 to *Kawano et al.* and in further view of paragraphs [0068]-[0069].

As noted by the Examiner, *Aaltonen et al.* "does not disclose the ruthenium precursors as required by claim 1," and claims dependent thereon (*See* Final Office Action mailed April 8, 2008, page 4). As claims 19 and 27 each recite the same ruthenium precursors as recited in claim 1, Applicant respectfully submits that the Examiner has also implicitly agreed that *Aaltonen et al.* does not disclose the ruthenium precursors recited in claims 19 and 27 and claims dependent thereon.

To solve the deficiencies of *Aaltonen et al.*, the Examiner has relied upon the teaching of *Kawano et al.* Applicants have argued that *Kawano et al.* describes a half-sandwich organometallic ruthenium compound in the CVD method that is a reactant to synthesize a precursor and is not the precursor itself.

The Examiner agrees with Applicants on this point and directs Applicants to Compound 7 as well as other ruthenium compounds described by *Kawano et al.* (*See* Examiner's Answer, Page 8).

Compound 7 of *Kawano et al.* provides a carbonylbis(diene)ruthenium complex (See Abstract and column 4, lines 26-58). While the Examiner notes that the ruthenium complex as described by *Kawano et al.* includes a carbonyl group, the Examiner states

[1] The underlined portion shows a modification to the rejection included in the Examiner's Answer dated December 29, 2008. Applicants submit that the text at paragraphs [0068] and [0069] does not qualify as "admitted prior art."

that "...the presence of a carbonyl group does not negate the compound is a bis(dialkylpentadienyl) ruthenium compound." (*See* Examiner's Answer, Page 8).

Applicants respectfully disagree with the Examiner. Established case law regarding obviousness of chemical compounds recognizes that a "...known compound may suggest its homolog, analog, or isomer..." (*Takeda Chem. Ind., LTD. v Alphapharm Pty., LTD.*, 492 F.3d 1350, 1356 (Fed. Cir. 2007)). However, the Federal Circuit mandates "...that in order to find a prima facie case of unpatentability in such instances, a showing that the 'prior art would have suggested making the specific molecular modifications necessary to achieve the claimed invention' was also required." Id. (citing *In re Deuel*)

Applicants respectfully submit that *Kawano et al.* is void of any teachings or suggestions to modify carbonylbis(diene)ruthenium complexes, such as compounds of general formula 7, by removing the carbonyl group – as suggested by the Examiner. Applicants respectfully submit that the Examiner has not provided evidence or logic as to why the skilled artesian would be motivated to modify the carbonylbis(diene)ruthenium complexes. Applicants submit that *Kawano et al.* describes a need for the carbonylbis(diene)ruthenium complex or the half-sandwich organometallic ruthenium compound, which are derived from the open ruthenocene compounds represented by general formula 3. The carbonylbis(diene)ruthenium complexes are taught by *Kawano et al.* to be favorable compounds for vapor deposition processes. *Kawano et al.* further teaches that a non-carbonyl compound, such as (cyclopentadienyl) (2,4-dimethylpentadienyl) ruthenium, "cannot be considered as a suitable CVD precursor, since it has a melting point of 136 to 137°C and occurs as a solid at ordinary temperature." (*See* column 2, lines 9-19).

Further, *Kawano et al.* to teaches the formation of the half-sandwich organometallic ruthenium compound and/or the formation of carbonylbis(diene)ruthenium complexes by adding a carbonyl group to modify the open ruthenocene compounds, in lieu of using the open ruthenocene compounds itself, suggests a teaching away from a ruthenium precursor without a carbonyl group, especially the open ruthenocene compounds. (*See* column 2, lines 51-59). Thus,

Applicants submit that a prima facie case of obviousness has not been set forth by the Examiner.

Therefore, *Aaltonen et al.* and *Kawano et al.*, alone or in combination, do not teach, show, or suggest a method for forming a ruthenium material on a substrate surface, comprising positioning a substrate within a process chamber, exposing a ruthenium-containing compound to the substrate while forming a ruthenium-containing compound film thereon, wherein the ruthenium-containing compound is selected from the group consisting of bis(dialkylpentadienyl) ruthenium compounds, bis(alkylpentadienyl) ruthenium compounds, bis(pentadienyl) ruthenium compounds, and combinations thereof, purging the process chamber with a purge gas, exposing a reducing gas comprising ammonia and atomic hydrogen to the ruthenium-containing compound film on the substrate while forming a ruthenium layer thereon, and purging the process chamber with the purge gas, as recited in claim 1, and claims dependent thereon. Withdrawal of the rejection is respectfully requested.

Additionally, *Aaltonen et al.* and *Kawano et al.*, alone or in combination, do not teach, show, or suggest a method for forming a ruthenium material on a substrate, comprising depositing a barrier layer on a substrate during a first ALD process, wherein the barrier layer comprises a material selected from the group consisting of tantalum, tantalum nitride, tantalum silicon nitride, titanium, titanium nitride, titanium silicon nitride, tungsten, tungsten nitride, and combinations thereof, and exposing the substrate sequentially to a ruthenium-containing compound and a reducing gas comprising ammonia to form a ruthenium layer on the barrier layer during a second ALD process, wherein the ruthenium-containing compound is selected from the group consisting of bis(dialkylpentadienyl) ruthenium compounds, bis(alkylpentadienyl) ruthenium compounds, bis(pentadienyl) ruthenium compounds, and combinations thereof, as recited in claim 19, and claims dependent thereon. Withdrawal of the rejection is respectfully requested.

Also, *Aaltonen et al.* and *Kawano et al.*, alone or in combination, do not teach, show, or suggest a method for forming a ruthenium film on a dielectric material disposed on a substrate surface, comprising positioning a substrate comprising a dielectric layer thereon within a process chamber, exposing a ruthenium-containing

compound to the dielectric layer while forming a ruthenium-containing compound film thereon, wherein the ruthenium-containing compound is selected from the group consisting of bis(dialkylpentadienyl) ruthenium compounds, bis(alkylpentadienyl) ruthenium compounds, bis(pentadienyl) ruthenium compounds, and combinations thereof, purging the process chamber with a purge gas, exposing a reducing gas comprising ammonia to the ruthenium-containing compound film on the dielectric layer while forming a ruthenium layer thereon, and purging the process chamber with the purge gas, as recited in claim 27, and claims dependent thereon. Withdrawal of the rejection is respectfully requested.

Applicant submits that the half-sandwich organometallic ruthenium compound precursor used in the CVD process of *Kawano et al.* also is not bis(2,4-dimethylpentadienyl) ruthenium as recited in claims 11, 54, and 55. The precursor used to synthesize the half-sandwich organometallic ruthenium compound precursor may be bis(2,4-dimethylpentadienyl) ruthenium if one of ordinary skill in the art selects the proper R^2, R^3, and R^4 groups from a laundry list of possibilities, but such ruthenium compound is never exposed to the substrate in *Kawano et al.* Applicant respectfully submits that one of ordinary skill, when confronted with *Kawano et al.*, would utilize the half-sandwich organometallic ruthenium compound as a ruthenium precursor. Applicant respectfully submits that one of ordinary skill in the art, when confronted with *Kawano et al.*, would not utilize the bis(pentadienyl) ruthenium compound as a precursor in a deposition process. Applicant additionally respectfully submits that one or ordinary skill in the art would not select the specific ruthenium compound of bis(2,4-dimethylpentadienyl) ruthenium from a laundry list of possibilities absent hindsight. Therefore, Applicant respectfully submits that utilizing the bis(pentadienyl) ruthenium compound of *Kawano et al.* in the ALD process of *Aaltonen et al.* is not obvious.

Regarding the teaching of reducing gas in *Aaltonen et al.* and *Kawano et al.*, the Examiner has admitted that both *Aaltonen et al.* and *Kawano et al.* "do not explicitly teach using the combination of ammonia and atomic hydrogen as a reducing agent." (*See* Final Office Action mailed April 8, 2008, page 5). The Examiner proceeds to rely upon reducing agents disclosed in Applicant's specification.

Applicant's disclosure states "[s]uitable reducing gases may include traditional reductants, for example, hydrogen (e.g., H_2 or atomic-H), ammonia (NH_3) ..." (*See* paragraph [0068]). Applicant respectfully submits that even if the reducing gases disclosed in Applicant's specification are considered well known and/or traditional, one or ordinary skill in the art would not modify *Aaltonen et al.* to utilize such reducing gases based on *Aaltonen et al.*'s specific teaching of oxygen containing gases. Applicants respectfully submit that substituting *Aaltonen et al.*'s oxygen containing reducing gas, as proposed by the Examiner, utilizes hindsight and would destroy the teachings of *Aaltonen et al.* Therefore, Applicant respectfully submits that the Examiner's proposed modification of *Aaltonen et al.* is not obvious.

Therefore, *Aaltonen et al.* and *Kawano et al.*, alone or in combination, do not teach, show, or suggest a method for forming a ruthenium material on a substrate surface within a process chamber, sequentially comprising exposing a substrate to bis(2,4-dimethylpentadienyl) ruthenium to form a ruthenium-containing film on the substrate, purging the process chamber with a purge gas, exposing a reducing gas comprising ammonia to the ruthenium-containing film while forming a ruthenium layer thereon, and purging the process chamber with the purge gas, as recited in claim 11, and claims dependent thereon. Withdrawal of the rejection is respectfully requested.

Additionally, *Aaltonen et al.* and *Kawano et al.*, alone or in combination, do not teach, show, or suggest a method for forming a ruthenium material on a low-k material disposed on a substrate surface, comprising positioning a substrate comprising a low-k layer disposed thereon within a process chamber, heating the substrate to a temperature within a range from about 200°C to about 400°C, exposing the low-k layer to bis(2,4-dimethylpentadienyl) ruthenium to form a ruthenium-containing compound film thereon, purging the process chamber with a purge gas, exposing the ruthenium-containing compound film to a reducing gas comprising ammonia and atomic hydrogen while forming a ruthenium layer on the low-k layer, and purging the process chamber with the purge gas, as recited in claim 54, and claims dependent thereon. Withdrawal of the rejection is respectfully requested.

Also, *Aaltonen et al.* and *Kawano et al.*, alone or in combination, do not teach, show, or suggest a method for forming a ruthenium material on a barrier material layer

disposed on a substrate surface, comprising positioning a substrate comprising a tantalum-containing barrier layer disposed thereon within a process chamber, heating the substrate to a temperature within a range from about 200°C to about 400°C, exposing the tantalum-containing barrier layer to bis(2,4-dimethylpentadienyl) ruthenium while forming a ruthenium-containing compound film thereon, purging the process chamber with a purge gas, exposing the ruthenium-containing compound film to a reducing gas comprising ammonia and atomic hydrogen while forming a ruthenium layer on the tantalum-containing barrier layer, and purging the process chamber with the purge gas, as recited in claim 55, and claims dependent thereon. Withdrawal of the rejection is respectfully requested.

Aaltonen et al. discloses "placing a substrate in a reaction chamber within a reactor," "providing a vaporized noble metal precursor into the reaction chamber to form a single molecular layer of the precursor on the substrate," "removing excess vaporized precursor from the reaction chamber", "providing a second reactant gas comprising oxygen to the reaction chamber such that the oxygen reacts with the precursor on the substrate," and "removing excess reactant gas and reactant by-products from the reaction chamber." (*See* paragraph [0021]). *Aaltonen et al.* performs an ALD method (*See* paragraph [0034]) and recognizes "the general limitations of the CVD method, such as problems related to achieving good large area uniformity and accurate thickness control" (*See* paragraph [0012]).

Kawano et al., contrary to the teachings of *Aaltonen et al.*, discloses a CVD process for forming a ruthenium-containing thin film. (*See* col. 3, lines 17-22).

Therefore, *Aaltonen et al.* and *Kawano et al.*, alone or in combination, do not teach, show, or suggest a method for forming a ruthenium material on a substrate surface, comprising positioning a substrate within a process chamber, exposing the substrate to a ruthenium-containing compound comprising ruthenium and at least one open chain dienyl ligand while forming a ruthenium-containing compound film thereon, purging the process chamber with a purge gas, exposing the ruthenium-containing compound film to a reducing gas comprising ammonia and hydrogen gas while forming a ruthenium layer on the substrate, and purging the process chamber with the purge

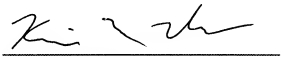
gas, as recited in claim 36, and claims dependent thereon. Withdrawal of the rejection is respectfully requested.

Also, *Aaltonen et al.* and *Kawano et al.*, alone or in combination, do not teach, show, or suggest a method for forming a ruthenium material on a low-k material disposed on a substrate surface, comprising positioning a substrate comprising a low-k layer disposed thereon within a process chamber, heating the substrate to a temperature within a range from about 200°C to about 400°C, exposing the low-k layer to a ruthenium-containing compound comprising ruthenium and at least one open chain dienyl ligand while forming a ruthenium-containing compound film thereon, purging the process chamber with a purge gas, exposing the ruthenium-containing compound film to a reducing gas comprising ammonia while forming a ruthenium layer on the low-k layer, and purging the process chamber with the purge gas, as recited in claim 44, and claims dependent thereon. Withdrawal of the rejection is respectfully requested.

CONCLUSION

For the reasons stated above, Applicants respectfully submit that the rejection of claims 1, 2, 4-7, 9-14, 16, 17, 19, 20, 22-25, 27, 28, 30-33, 35-38, 40-42, 44-46, 48-51, and 53-67 is improper. It is respectfully requested that the Board reverse the findings of the Examiner.

Respectfully submitted,



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